Survey of *Semiothisa fraserata* (Geometridae) and *Gazoryctra sciophanes* (Hepialidae) in the Southern Appalacians

by
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Cover illustration: Area of Fraser fir decline above carpark at Waterrock Knob, North Carolina.

Introduction

The swift moth *Gazoryctra sciophanes* (Ferguson, 1979) and the geometrid moth *Semiothisa fraserata* Ferguson 1974 are currently listed as category 2 species on the US Fish and Wildlife's (Service) List of Endangered and Threatened Wildlife and Plants: Animal Candidate Review for Listing as Endangered or Threatened Species (56 FR 58804). This category was established on the basis of available information indicating that their proposed status as endangered or threatened species may be appropriate, but for which conclusive data on biological vulnerability and threat are not currently available.

The reason for this concern was that both species are southern Appalachian endemics confined to Fraser fir forests which has undergone dramatic decline due to defoliation by the introduced balsam woolly adelgid. Large areas of extensive dieback may be followed by regeneration, but many areas have been depleted of Fraser fir cover and associated ecology (see cover illustration).

The larval biology of *G. sciophanes* is unknown, but larvae are likely to feed on roots of Fraser fir and other conifer species or other plants associated with the spruce/fir habitat. Larvae of *S. fraserata* feed on foliage of Fraser fir and possibly other conifers. Degradation or destruction of the Southern Appalachian Fraser fir/red spruce forests may have significant detrimental impacts on the long-term survival of the two moth species.

Both insects are comparatively recent discoveries. *G. sciophanes* was first described from nineteen specimens collected at Waterrock knob, Jackson Co., North Carolina in mid-July of 1979 (Ferguson, 1979). It is a member of the ghost moth family Hepialidae representing about 500 species worldwide. In North America the genus *Gazoryctra* ranges across much of Canada, and the Rocky Mountains south to Arizona, but is absent from the central and northern Appalachians. At present the known distribution range of *G. sciophanes* is limited to the Southern Appalachians in North Carolina and Virginia (Fig. 1).

The Fraser fir moth *Semiothisa fraserata*, was first described in 1974 as a new species of a genus comprising about 90 North American species (Ferguson 1974). It is currently recognized as a southern Appalachian endemic confined to habitats dominated by Fraser fir above about 6,000 feet elevation.

Methods

Brief sampling for the adult moths was carried out in July of 1995 and 1996. The replication of sampling was to provide an exploratory survey to become familiar with the local region, allow for possible variability in sample size due to weather, and to accommodate variability due to any extended multi-year life history development for the ghost moth in particular.

Moths were trapped at several sites in North Carolina within a day's drive of Asheville, and two sites in Virginia in the Mount Rogers Recreational Area (Maps 1-5). Sites were chosen for accessibility to spruce/fir forest (with the exception of Licklog Gap chosen as a control site outside the spruce/fir habitat) from the road for light and sticky traps. The Mount Rogers National Recreation Area in Virginia was selected to determine whether the northern limit of *G. sciophanes* may be correlated with the northern limit of Fraser Fir forest. Due to time and budgetary constraints sampling was limited to a single night.

(a) Site descriptions

(i) **Richland Balsam Mountain.** Just below lookout on Blue Ridge Parkway at 5,580' elevation, and Licklog Gap Overlook at 5,135' elevation (Map 1).

(iv) **Waterrock Knob**. Overlook carpark at 6,000 elevation surrounded by patches of Fraser fir and hardwood/herb regeneration (Map 1).

(ii) **Roan Mountain.** (a) Carvers Gap. Park entrance at 5,512' elevation. Light trap and sticky traps under canopy of spruce and fir; (b) Sticky traps 1.4 miles from Carvers Gap adjacent to summit road; (c) Light trap at summit carpark (Map 2).

(v) **Mount Mitchell:** (a) Adjacent to 250 acre experimental forest planting. Mixed hardwood-spruce/fir forest; (b) Fraser fir forest at 6,000' (c) Sticky traps in Fraser fir forest opposite entrance to restaurant, and halfway between restaurant and summit (Map 3).

(iii) **Smoky Mountains National Park.** Indian Gap, located 1.1 miles from Newfound Gap, along road to Clingman's Dome (Map 4).

(vi) **Mount Rogers National Recreational Area:** (a) Blacklight for single night at Wilburn Ridge, Mount Rogers, within scattered Fraser fir forest; (b)

Mercury vapor light next to transmitter station adjacent to spruce forest on summit of Whitetop Mountain (Map 5).

(b) Equipment

Light traps: Moths were collected from a portable, battery powered, 15W blacklight positioned vertically above a collecting bin, and a generator powered 150W mercury vapor lamp positioned in front of a white cotton collecting sheet. Blacklight traps were placed within the forest canopy, while the mercury vapor collecting was limited to the roadside to accommodate the gas-powered generator.

Flight intercept traps: Clear polyethylene sheets coated with tangletrap[R] were tied to wooden stakes and suspended with the lower edge about 1 m from the ground. In 1995 traps were placed about 30 m above the carpark (10 traps) and western edge of the carpark (5 traps) at Waterrock Knob.

In 1996 10 intercept traps were established at each of the following localities:
(1) Roan Mountain - Carver's Gap under a spruce canopy, and 1.4 miles from park entrance among spruce/fir windthrow and regeneration.
(2) Mount Mitchell - (a) Spruce forest next to access road 2 miles from Park entrance; (b) Fraser Fir forest opposite restaurant; (c) half-way to summit from restaurant.

RESULTS

(A) Light traps

(i) 1995: A total of eight specimens of *G. sciophanes* were collected, all from the roadside of Blue Ridge Parkway, Mount Mitchell. *Semiothisa* specimens were sent to Carnegie Museum of Natural History and the preliminary identification by Dr. John Rawlins confirmed only *S. signaria* (Table 1), but subsequently these were identified as a mixture of *S. signata* and *S. fraserata* forms (see discussion below). Larvae were reared from three females.

Table 1. Light trap collections of *Semiothisa* from 1995 collecting.

	fraserata	*ulserata*	*quadtrinotaria*
Newfound Gap	4	-	-
Mount Mitchell	10	2	-
Waterrock Knob	27	2	1

(ii) 1996:

Specimens of both moths were collected from all North Carolina sites sampled (Tables 2-3), but none from the Mount Rogers National Recreation Area

Table 2. Light trap collections of Hepialidae 1996

Locality	*G. sciophanes*	*K. gracilis*	*S. auratus*
Indian Gap	-	-	-
Mt. Mitchell (5,300)	14	-	1
Mt. Mitchell (6,000)	8	1	-
Richland Balsam	-	-	-
Waterrock Knob	3	-	-
Clingman's Dome Rd.	-	-	-
Roan Mt. Carvers Gap	3	2	-
Whitetop Mt.	-	-	-

Table 3. Light trap collections of Semiothisa in 1996

Locality	*fraserata*	*ulserata*	*quadrinotaria*
Indian Gap	15	9	2
Mt. Mitchell (5,300)	31	7	1
Mt. Mitchell (6,000)	17	-	-
Richland Balsam	37	6	-
Waterrock Knob	23	3	1
Clingman's Dome Rd.	3	-	2
Carver's Gap	7	-	-
Roan Mt. Summit	16	-	-
Whitetop Mt.	-	4	-

(B) Flight Intercept traps

	G. sciophanes	*K. gracilis*
Waterrock Knob 1995	-	37
Roan Mt: Carvers Gap	2	3
Roan Mt.	3	0
Mt. Mitchell (a)	0	0
Mt. Mitchell (b)	5	1
Mt. Mitchell (c)	2	0

(C) *Semiothisa* Rearing

Adults were reared from eggs obtained from three specimens identified as *Semiothisa signaria dispuncta* by Dr. J. Rawlins at the Carnegie Museum of Natural history (Appendix 1). The wing patterns of reared specimens were found to be variable and encompassed the range of coloration found in typical *S. fraserata* and *S. signata.* The size of reared specimens was typical for *S. signaria.* There was a tight synchronization of adult emergence based on simultaneous rewarming of pupae. There was no evidence of emergence without wintering, and therefore no evidence of a second brood under the conditions of rearing (Rawlins, pers. comm.).

HISTORIC COLLECTION RECORDS

(a) Semiothisa fraserata

Richland Balsam Mountain (Jackson-Haywood county Line), Mount Mitchell (Yancy County), Black Mountains (Bundcomb County?). Specimens deposited with the US National Museum (Ferguson, 1974).

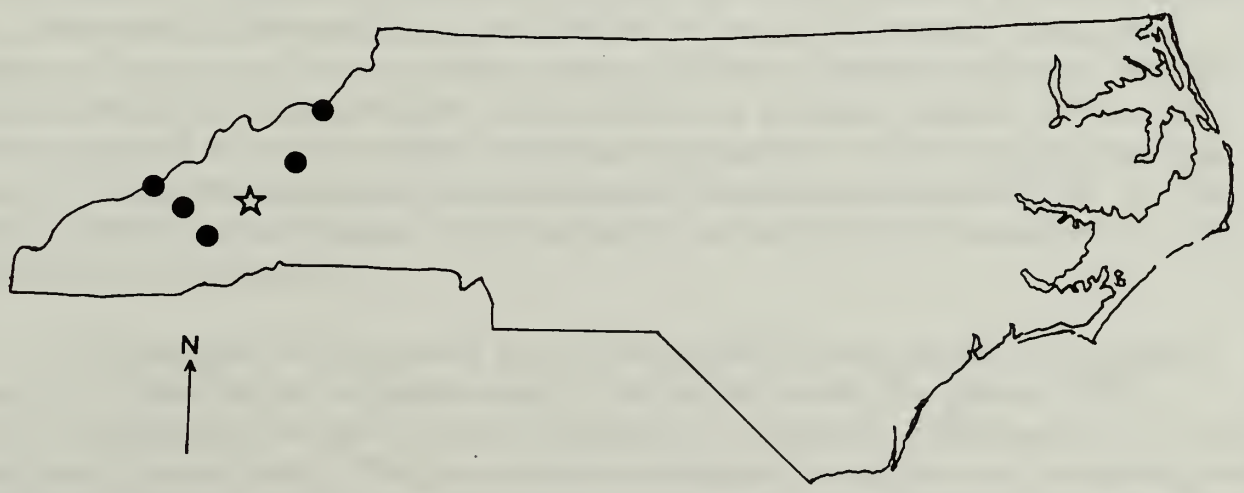
(b) Gazoryctra sciophanes

Waterrock Knob, 16-17 July 1974. Specimens deposited with the US National Museum, Canadian National Collection, British Museum of Natural History, and the Norman B. Tindale Collection, California (Ferguson, 1979).

Shining Rock Wilderness Area, 6,000', 5 miles west of Black Balsam Knob (Haywood County). July 30, 1983. Specimen deposited with the American Museum of Natural History.

West Virginia. Precise locality not currently available.

Fig. 1. Geographic distribution of records for *Gazoryctra sciophanes* (solid circles) in North Carolina. Star = Asheville.



DISCUSSION

(a) Taxonomic status of *Gazoryctra sciophanes*

This ghost moth was originally described by Ferguson (1979) under the name *Hepialus sciophanes*. Its taxonomic status was later revised by Wagner and Tindale (1988) who transferred the species to the genus *Gazorytra*. This genus was first established by Hübner (1820) for a European species, but not until Viette (1949) was the genus extended to include any American species. Wagner and Tindale (1988) verified the validity of the genus and listed a total of 13 species, of which 10 are from North America.

It is probable that *G. sciophanes* is the sole representative of its genus in the southern Appalachians. It is easily distinguishable from the two other hepialid species with overlapping geographic and topographic ranges. The conifer swift moth,*Korscheltellus gracilis*, is widespread and common in the boreal conifer forests and high elevation spruce/fir forests of the Appalachian Mountains (Wagner, 1988). The 32 mm wingspan of *K. gracilis* is smaller than the 35 mm of *G. sciophanes*, and the wings of *K. gracilis* are mottled with scattered brown tan, or gray scales while wings of male *G. sciophaness* are an even sooty-black color with patches of white or silver, and the females are light yellow-brown with patches of darker scales (Fig. 2a).

The third hepialid found in this survey is *Sthenopis auratus* which feeds on ostrich fern and other ferns associated with hardwood forests in the Appalachians (McCabe and Wagner, 1988). It is unlikely to be found with *G. sciophanes* other than in the transitional zone from hardwoods to conifers. The wingspan of *S. auratus* is about 55 mm or greater and the wing color is light yellow-brown with scattered gold colored scales (Fig. 2b).

(b) Taxonomic status of *Semiothisa fraserata*

Specimens of *S. fraserata* have only been collected from the southern Appalachians in the vicinity of Asheville. Ferguson (1974, p. 581) first intended to treat the moth as a subspecies of *Semiothisa signaria*, but the presence of "normal" *Semiothisa signaria dispuncta* at lower elevations along with other *Semiothisa* species led to the conclusion that the high elevation form qualified as a distinct species. *S. fraserata* was considered to be most similar in size and appearance to the large Pacific coast form *of S. signaria dispuncta*, but more heavily marked and blackish (Fig. 3). The more brightly colored females were considered to resemble the females of *S. oweni*, except for their larger size.

The genitalia of *S. fraserata* are indistinguishable from those of *S. signaria*, except for being larger in proportional to the larger moths (Ferguson, 1974). External markings also provide no distinguishing characters. Differences in external morphology described by Ferguson were represented by extremes of morphological variation. Males of *S. fraserata* differed from those *S. signaria dispuncta* by having

"more" white ground color, and the forewing lines and spots being "more complete and darker", nearly black. The medial line of *S. fraserata* was more commonly present and complete, and the subapical costal and median subterminal spots were better developed and virtually black. Similarly, the female also differed from that of *S. signata dispuncta* in the contrast between light and dark areas being "greater".

Adults of *S. fraserata* and *S. signaria dispuncta* are illustrated in Fig. 2. There are no characters to distinguish the two species from each other. Adults reared from eggs collected from specimens of *S. fraserata* exhibited no consistent differences that would separate them from *S. signaria dispuncta.*

The flight period of 23 June to 5 July documented by Ferguson (1974) *for S. signaria* in North Carolina is almost the same as 20 June to 3 July for *S. fraserata.* This emergence synchrony does not support the hypothesis that the two are separate species.It would seem very likely that *S. fraserata* represents a morphological variant of *S. singaria dispuncta* that is limited in geographic range too the high elevation spruce/fir forests of the Southern Appalachians. After rearing specimens of *S. signaria* Dr. J. Rawlins (personal communication) concluded that *S. fraserata* is nothing more than a higher elevation form of *S. signaria*, and development of *S. fraserata* larvae at lower average temperatures explains their slightly larger size.

(c) Population status

The survey was too limited and lacked the necessary replications and comparisons with non-threatened habitats to quantify and characterize the population status of either moth. Both species were collected in a small sample size and this may suggest that if the decline of Fraser fir is having a negative impact on these species, the habitat deterioration has not yet reached a point where their survival status is critical.

(d) Threats

Both insects may be considered secure at present. The only environmental threat to their long-term survival would be the complete degradation of the spruce/fir forest habitat and its replacement by non-confierous vegetation. Such conversion has occurred locally (e.g. some areas immediately above carpark at Waterrock Knob), but at present there remain extensive areas of fir and spruce forest which would continue to support both insects.

Conclusions and Recommendations

(1) Status of species

Neither insect is under immediate survival threat from commercial, sporting, scientific or educational activities. There is no information on the role or impact of diseases or predation on the populations of these insects. It is unnecessary at present to implement any State or Federal regulatory mechanisms to prevent decline of

either species other than those which will ensure the continued ecological integrity of the spruce/fir habitat.

Neither insect warrants continued classification as threatened or endangered at this time, but this should be reconsidered if degradation of fir forest continues.

(2) Essential habitat

Both insects are restricted to areas of spruce/fir forest, but their presence in areas with only patchy conifer cover suggests that they are able to survive in the region as long as there remain sufficient areas of conifer forest. How much spruce or fir forest is essential to maintain a long-term viable population is unknown and beyond the scope of this survey. It may be unlikely that the insects will survive where the conifer species are reduced to scattered trees.

(3) Management and Recovery

No specific management policies are necessary at this time.

(4) Research Needs

Future surveys will be desirable if the spruce/fir habitat undergoes further decline.

Acknowledgements

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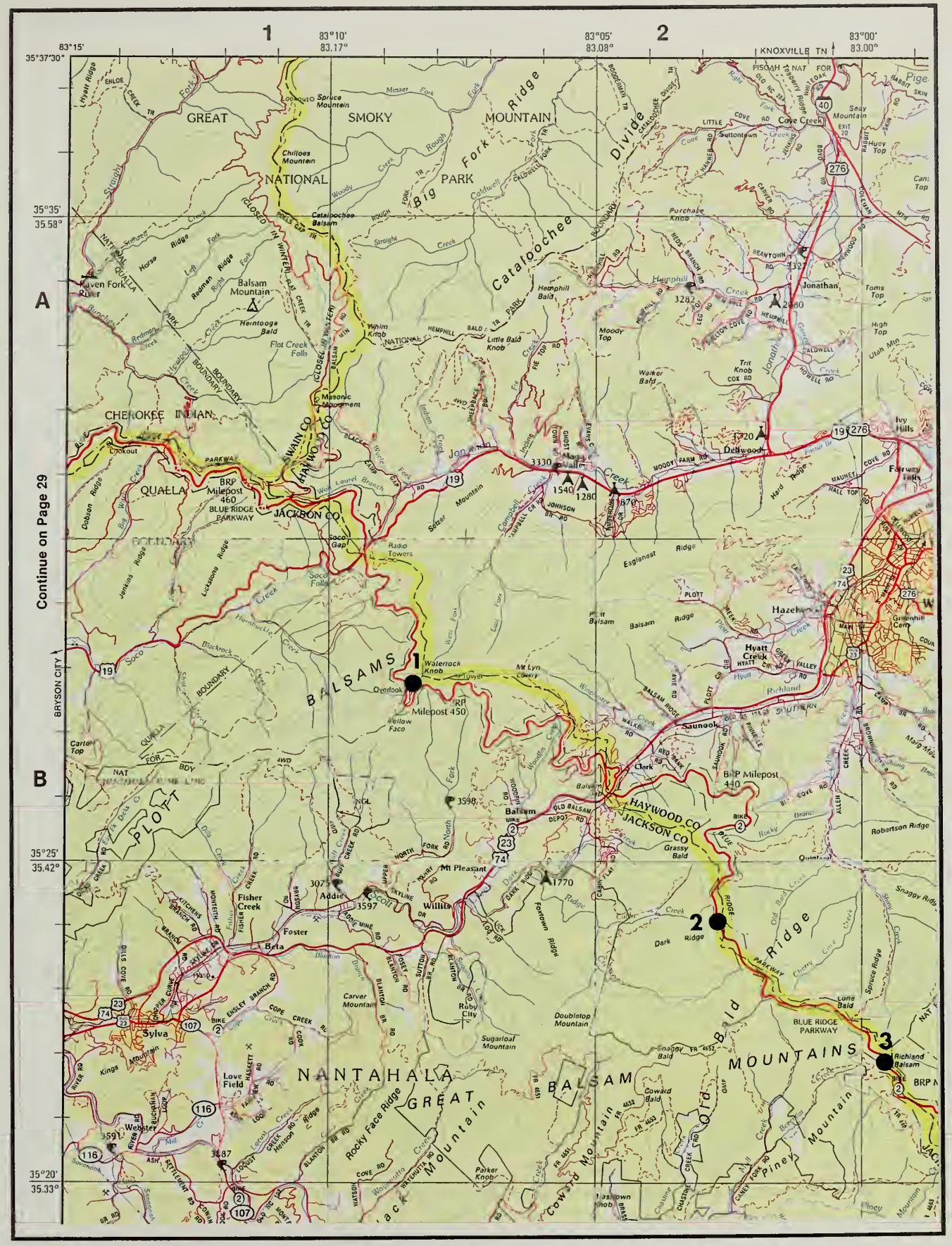
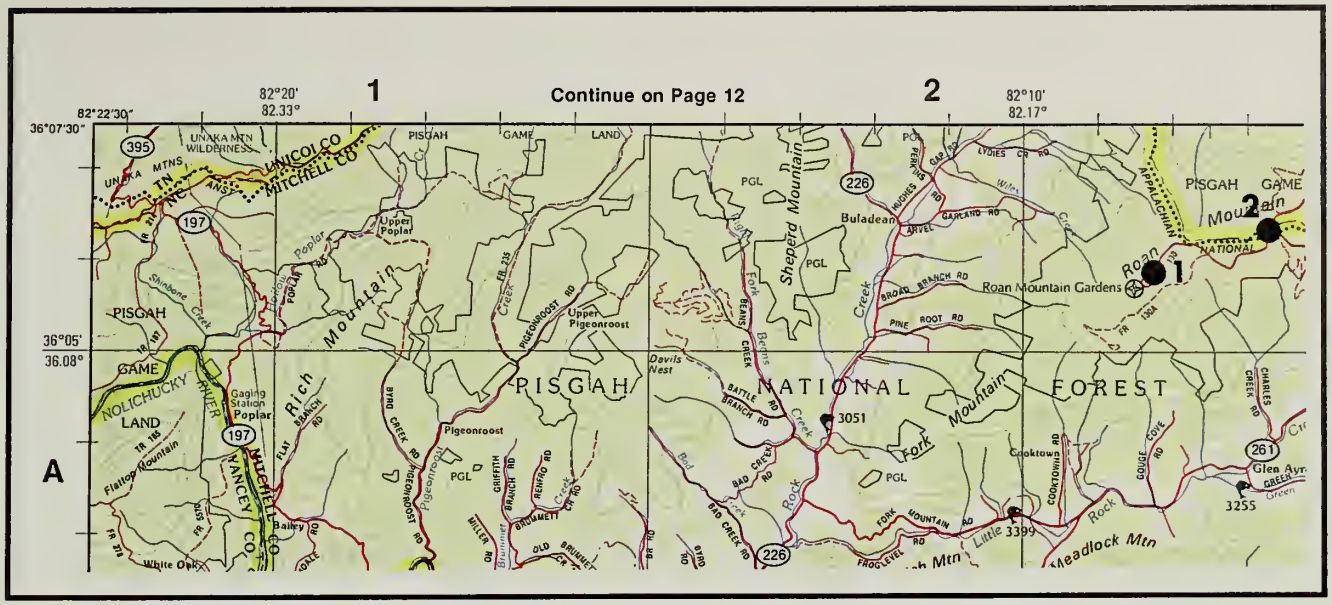
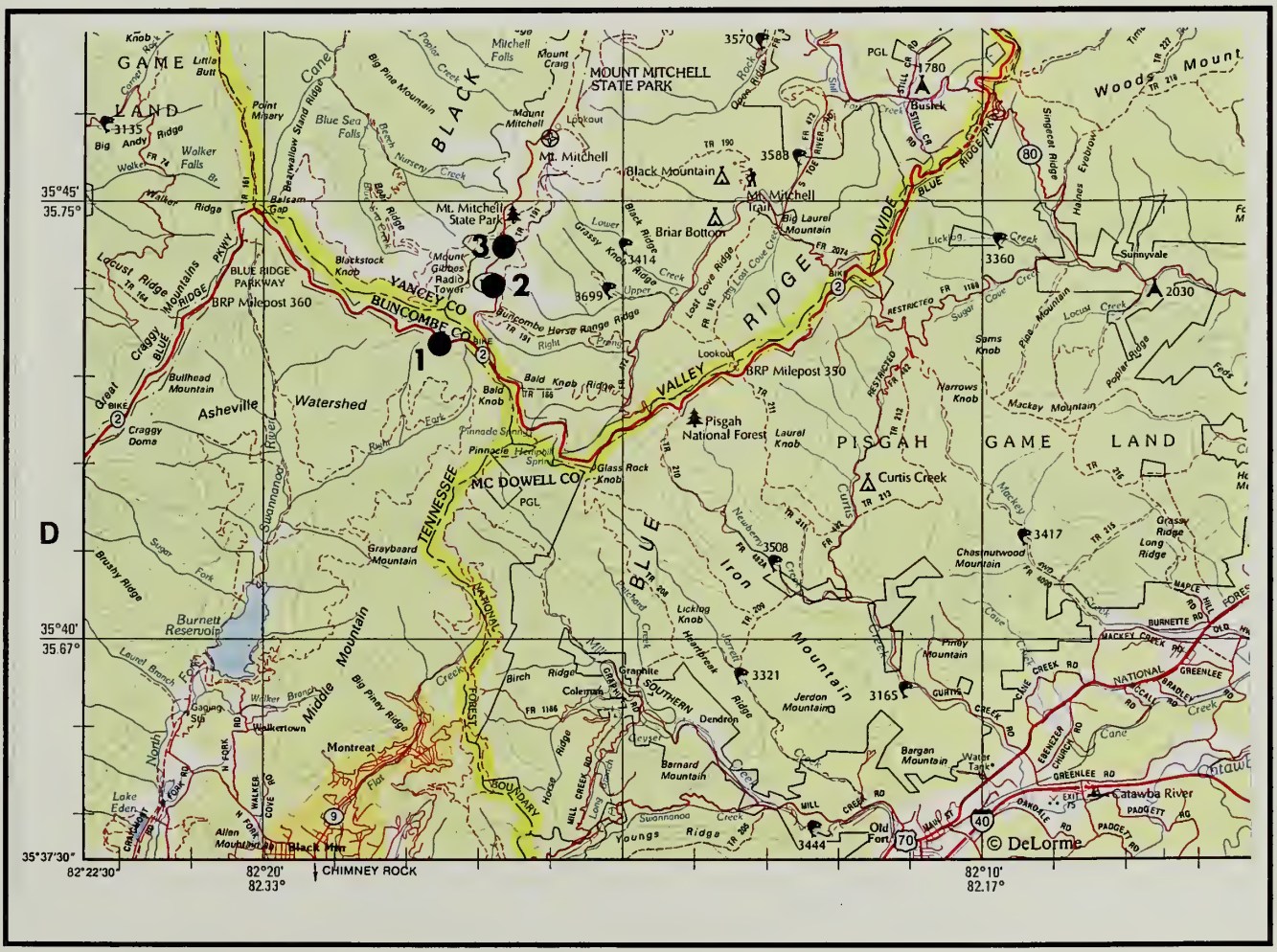


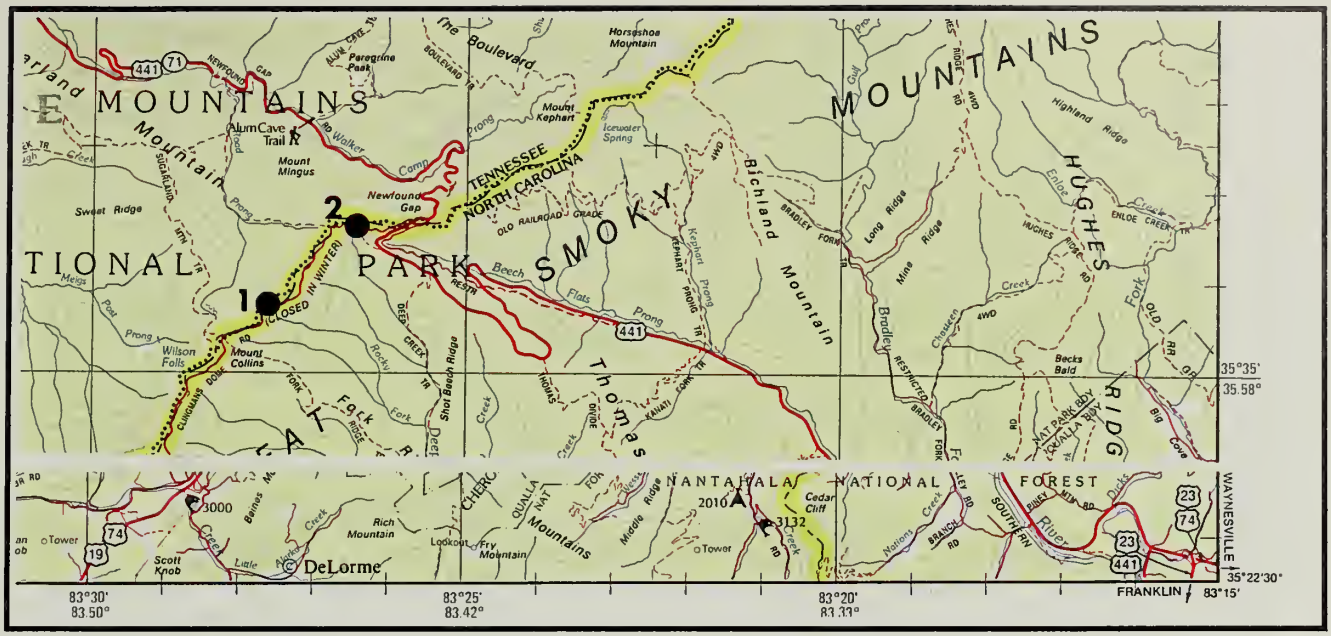
Map 1. Collecting sites: 1- Waterrock Knob, 2 - Licklog Gap, 3 - Richland Balsam Mountain



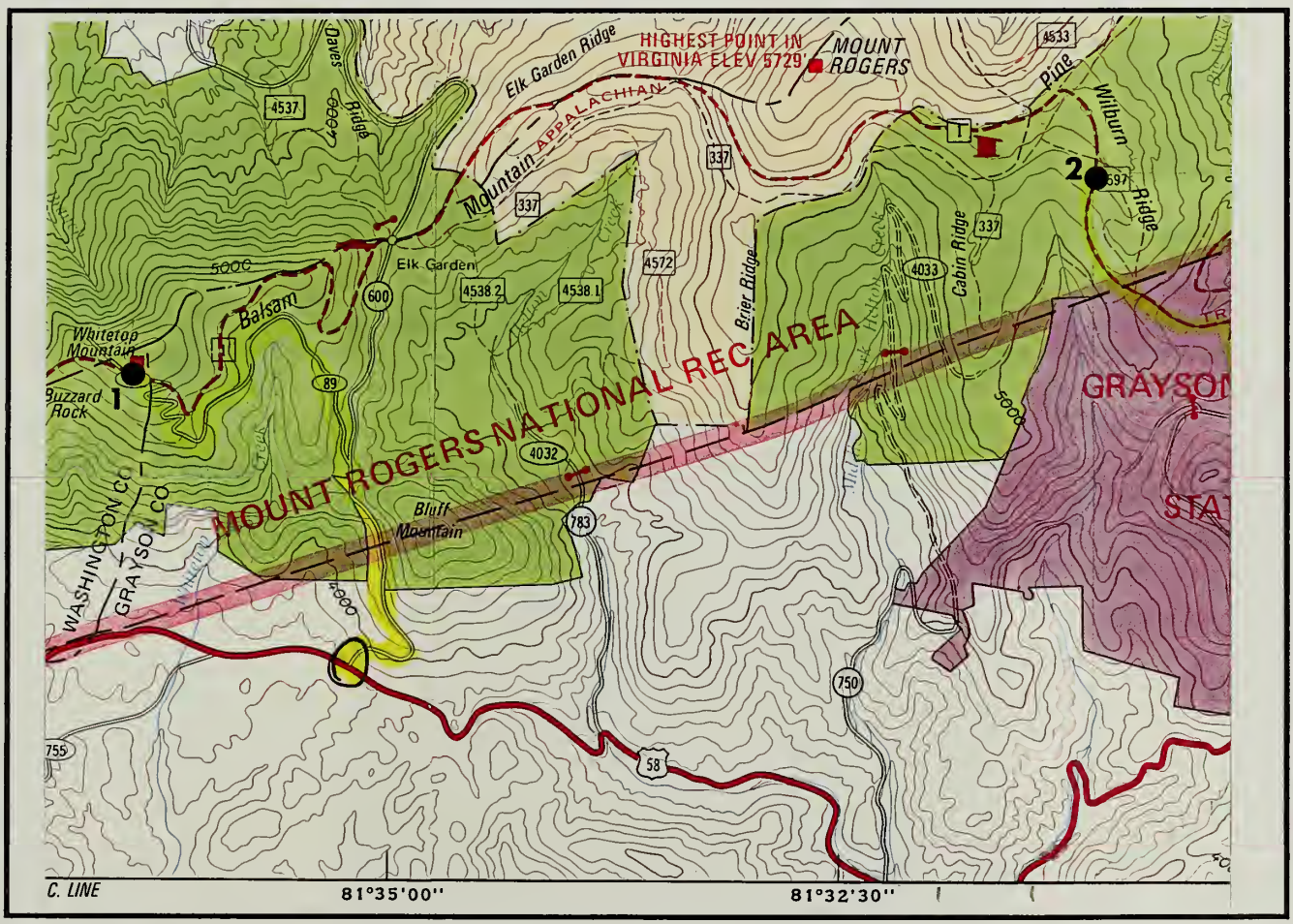
Map 2. Collecting sties: Roan Mountain; Summit (1), Car Park (2).



Map 3. Collecting sties: Mount Mitchell; Blue Ridge Highway roadside (1), Mt Mitchell Park entrance (2), and opposite restaurant entrance (3).



Map 4. Collecting sties: Clingmans Dome Road; Roadside (1), Indian Gap (2)



Map 5. Collecting sites. Mount Rogers: 1 - Whitetop Mountain, 2 - Wilburn Ridge.

Fig. 2a. Hepialidae. Top row: *Gazoryctra sciophanes* male (left), female (right). Bottom row: *Korscheltellus gracilis* from Mount Mansfield (left), and Mount Mitchell (right)

Fig. 2b. Hepialidae. *Sthenopis auratus*. Top: male, bottom: female.

Fig. 3. *Semiothisa signaria dispuncta* (50-59), *Semiothisa fraserata* (62-70). Left column figured only (figures from Ferguson, 1974).

Appendix 1

Rearing of *Semiothisa signaria dispuncta* (Walker) (presumably *Semiothisa fraserata* Ferguson) from material collected in North Carolina. Specimens reared by john Rawlins, Carnegie Museum of Natural History.

CMNH CULTURE NUMBER 95-109

Semiothisa signaria dispuncta (Walker)

Locality: North Carolina: Buncombe Co., Blue Ridge Parkway, 1 km from Mt. Mitchel State Park, 35-42-30N, 82-16-00W, 1580 m, 15 July 1995, J. R. Grehan, M. S. Griggs.
Female collected: 15 July 1995
Eggs laid: 16 July 1995
Egg hatch: 22 July 1995
Laboratory hosts: *Abies* sp. and *Tsuga canadensis*, both eaten readily, but the latter used primarily for rearing.
First pupa: 22 August 1995
Adults: first, 2 May 1996; second, 3 May 1996; third, 4 May 1996. Total vouchers kept: 2 adults.

CMNH CULTURE NUMBER 95-110

Semiothisa signaria dispuncta (Walker)
Locality: North Carolina: Buncombe Co., Blue Ridge Parkway, 1 km from Mt. Mitchel State Park, 35-42-30N, 82-16-00W, 1580 m, 15 July 1995, J. R. Grehan, M. S. Griggs.
Female collected: 15 July 1995
Eggs laid: 16 July 1995
Egg hatch: 22 July 1995
Laboratory hosts: *Abies* sp. and *Tsuga canadensis*, both eaten readily, but the latter used primarily for rearing.
First pupa: 20 August 1995
Adults: first 4 May 1996. Total vouchers retained: one adult.

CMNH CULTURE NUMBER 95-111

Semiothisa signaria dispuncta (Walker)
Locality: North Carolina: Buncombe Co., Blue Ridge Parkway, 1 km from Mt. Mitchel State Park, 35-42-30N, 82-16-00W, 1580 m, 15 July 1995, J. R. Grehan, M. S. Griggs.
Female collected: 15 July 1995
Eggs laid: 16 July 1995
Egg hatch: 22 July 1995
Laboratory hosts: *Abies* sp. and *Tsuga canadensis*, both eaten readily, but the latter used primarily for rearing.
First pupa: 22 August 1995
Adults: first 1 May 1996; three adults 2 May 1996; one adult 3 May 1996; two adults 4 May 1996; one adult 5 May 1996. Total vouchers retained: 6 adults.

CMNH CULTURE NUMBER 95-112

Semiothisa signaria dispuncta (Walker)
Locality: North Carolina: Buncombe Co., Blue Ridge Parkway, 1 km from Mt. Mitchel State Park, 35-42-30N, 82-16-00W, 1580 m, 15 July 1995, J. R. Grehan, M. S. Griggs.
Female collected: 15 July 1995
Eggs laid: 16 July 1995
Egg hatch: 22 July 1995
Laboratory hosts: *Abies* sp. and *Tsuga canadensis*, both eaten readily, but the latter used primarily for rearing.
First pupa: 21 August 1995

Adults: first 3 May 1996; two adults 4 May 1996; two adults 5 May 1996. Total vouchers retained: 4 adults.

CMNH CULTURE NUMBER 95-113

Semiothisa signaria dispuncta (Walker)

Locality: North Carolina: Jackson Co., 0.7 km SW Waterrock Knob, 35-27-30N, 83-08-20W, 1770 m, 14 July 1995, J. R. Grehan, M. S. Griggs.

Female collected: 14 July 1995

Eggs laid: 15 July 1995

Egg hatch: 21 July 1995

Laboratory hosts: *Abies* sp. and *Tsuga canadensis*, both eaten readily, but the latter used primarily for rearing.

First pupa: 21 August 1995

Adults: Seven adults 2 May 1996; two adults 4 may 1996. Total vouchers retained: 9 adults.